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CENTER OF GRAVITY  
OR  
STRANGE ATTRACTOR?

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College, Department of the Navy or the United States Air Force.

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15. Abstract: Center of gravity (COG) is a powerful concept for military practitioners. Unfortunately, in an attempt to quantify some aspect of an adversary's power, the term is used interchangeably with military objective. I argue that Clausewitz tried to describe the nonlinear nature of the battlefield, and lacking a scientific paradigm, "sold out" to the use of a linear description. This complicates present day use of this important concept. Because we attempt to find the one thing ... "from which all power emanates," we are in danger of being locked in to one solution.  The strange attractor, a key element of Chaos Theory, is a better description of the nature of an adversary's power. The characteristics of the attractor explain the shifts and proliferation of concentrations of power. Furthermore, it explains the dynamics of war throughout all levels of the conflict. Additionally, I want to explain that the vocabulary of this element of Chaos Theory is not just a new way of explaining the same old thing. If this concept is understood, important differences in analysis will be apparent. This, hopefully, will lead to more effective use of military power.			
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## INTRODUCTION

The center of gravity is, "...the hub of all power and movement; on which everything depends."<sup>1</sup> This basic tenet of warfare, taken as gospel in our profession, has guided all military action from the strategic to the tactical level. Regardless of whether it is explicitly or implicitly designated, the concept serves to focus our thought into strategies and applications of force to overcome an enemy's center of gravity or protect our own. This appears to be a fairly straight forward exercise. However, history shows that it isn't. The problem: To correctly determine just what was, is, or will be the enemy's center of gravity (COG) and whether or not it was, is, or will be vulnerable to attack.

Historically, we reach conclusions. Suffice to say, we take for granted that the victor correctly determined his adversary's COG. Additionally, we assume that he correctly assessed his enemy's vulnerability and applied force decisively. However, as we examine the record we find that the COG tends to change it's nature over time. Specifically, we sometimes find it a difficult and debatable exercise to link the military objective of a particular phase of combat with the COG. Not only is this a problem, but the record shows that COGs tend to proliferate as we move from the strategic to tactical level. Under these conditions, the COG concept turns more into the principle of military objective and a danger exists that we will lose the real intent of military action.

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<sup>1</sup> Clausewitz, Carl von; On War; ed. and trans. by Michael Howard and Peter Paret; Princeton; Princeton University Press; 1984; pg 595-596

I do not dispute that concentrations of power exist at all levels of conflict. Accumulations of power are dangerous elements of an adversary's capability. Rather, what I suggest is that the nature of those concentrations is what we want to understand. My thesis is to turn the concept of the COG "upside down"; to understand that they cannot exist in isolation or of their own volition. They will change over time as a result of their own functions or from outside effects. In short, power does not emanate from a single hub on which all depends. Rather, power is a channeled activity into some manifestation from disparate elements. In other words, COGs are strange attractors.

Clausewitz understood, through first hand knowledge, the complexities of war. The threads running through an operation of this magnitude defied calculation; especially using linear mathematics and mechanistic science. Now, a couple of hundred years later, science has produced a new way of explaining dynamic processes; Chaos Theory. My purpose is not to "sell" the whole theory as a new paradigm to guide operational art. But, the attractor, a key element of the theory, describes the compelling reality behind the connotations of the COG. As a result, this method of interpretation allows us to explore the nature of an adversary's power and allows us to exert some measure of control against it.

Many of my colleagues will reject Chaos Theory. It is usually passed off as a "new" vocabulary for the way we've always done business. I believe this critique misses the point. I believe

this is so because humans describe and explain through the use of metaphor. That is all well and good. However, the risk is that we attach meaning to metaphors that were never there to begin with. Our center of gravity definition and the ideas that form it's theoretical basis are mutually exclusive concepts at a fundamental level. Alternatively, I will show that the attractor is a better concept to analyze and understand the nature of power and there are meaningful implications for military operations. I suspect that our most successful commanders were able to see this, albeit without Chaos metaphors. We mere mortals will have to do our homework.

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## COGs...

Obviously, if we accept Clausewitz's definition, and it appears that we do (see below), the COG can not stand if we want victory in an unlimited war. Alternatively, in limited war the COG needs weakening if we are to gain the political leverage we went to war for in the first place. I say this because of the last four words from the Doctrine for Joint Operations (JPUB 3-0) definition.

**"Those characteristics, capabilities, or localities from which a military force derives its freedom of action, physical strength, or will to fight."**

It is that will to fight we want to subdue, regardless of the enemy's power. Yet, by definition, we must allow for the possibility that the COG may be invulnerable to direct attack.<sup>2</sup> Additionally, we may be restricted by political mandates that, in turn, restrict our latitude for action. Therefore, in this scenario, we are forced to search for an indirect means of weakening the COG; some type of vulnerability in our enemy's sphere of influence. However, as we do that, we run the risk of confusing the focus of military action and it's associated military end state. There is little doubt that a common thread runs through the

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<sup>2</sup> Izzo, Lawrence L.; "The Center of Gravity is Not an Achilles Heel"; Military Review; Jan 1988; pg. 72

desired end state and what we perceive as the COG. Our Vietnam experience, as pointed out by many writers, serves as an example. We misunderstood, from the very beginning and perhaps still today, the nature of North Vietnam's power. Was it the Viet Cong? How about the NVA? In short, there is no "school solution."

Disregarding relative strength among adversaries, from a purely theoretical standpoint can a COG be vulnerable? Recall that the COG is the hub of all power and movement. If power emanates outward, the COG is envisioned as a rock. If there is a vulnerability, it may be the result of inappropriate attention or resource allocation at a strategic or operational level. Alternatively, what we see as a vulnerability may be inconsequential to the enemy; its destruction or loss has no perceived effect on his aims or will to fight. The upshot is, that as one moves further away from the COG, one may get stuck chasing phantoms and blurring the focus of military action. Once again, to keep focused, we are forced to consider the COG with all its capabilities and respond appropriately. As a result, we are left with two options: Advise our political masters that we should fight with overwhelming force or, lacking that commitment, advise that there is no military solution.

A sense of this dilemma is seen, somewhat obliquely, by foreign military writers familiar with our method of warfare. Sir John "Sandy" Woodward remarked on this aspect of U.S. methodology in considering his planning for the amphibious operation in the Falklands/Malvinas campaign. He could not, as the U.S. Marines

would, "... go straight through the front door, kicking it down, whether or not it happens to be locked."<sup>3</sup> Although we can argue that today's U.S. Marines will seek a different opening if available, the evolution of military doctrine since Vietnam pays homage to the underlying precept of the conceptual strength of an unknown future COG.

Perhaps the concept of the COG is so compelling because it offers a means to employ order and simplicity in a complex and disorderly environment. After all, it is a term that is familiar and denotes regularity; a type of linear expression ideally suited to focusing on the task at hand. Furthermore, as the complexity in a theater of operations increases we even allow for the existence of more than one COG. However, regardless of the size or scale of an inquiry, this would seem a contradiction in terms. For in an attempt not to violate the principle of **economy of force**, it is preferable to trace back all sources of an adversary's power, "... to the fewest possible sources, and ideally to one alone."<sup>4</sup> The question of whether or not we can synthesize an answer to these two potentially exclusive ideas, is what will frequently lead different people to arrive at different answers.<sup>5</sup>

Depending on where you sit, this may be an interesting academic exercise or a question of life or death. The problem is

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<sup>3</sup> Woodward, John and Robinson, Patrick; One Hundred Days, The Memoirs of the Falklands Battle Group Commander; Annapolis, Maryland; Naval Institute Press; 1992; pg. 132.

<sup>4</sup> Clausewitz; On War; pg. 617

<sup>5</sup> Izzo; pg. 77



that economy of force is a linear process applied to the underlying nonlinearity of the COG. As humans, we compound this problem because we think in terms of metaphors. For, example, to accept Clausewitz's ideas means to accept the Trinity, (people, government and military force) and it's continual ebbs and flows of direction, policy, and force. Even if this is at too high a level, one must concede that conditions at any level of war are never static. However, we may say that the COG is dynamic, but when we think about it, it turns into a mechanical construct, courtesy of high school math and physics based on the writings of Sir Isaac Newton.<sup>6</sup> We want clear, concise and predictable answers as a requirement. The mistaken assumption is that the only things that stand in our way to that answer are incomplete information and resistance; the omniscient fog and friction of war.

I would argue that Clausewitz's ideas of power are as relevant today as they have ever been. He got the concept right. Unfortunately, he could only use terms that were known to the relatively educated. Our dilemma, as highly educated officers, is that we understand the concept of gravity too well. This in turn, confuses what we really want to know: The nature of an adversary's power and not necessarily the battlefield objective. Once we have a new construct, we can tackle the problem of affecting it in ways that lead to our advantage.

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<sup>6</sup> Beyerchen, Alan; "Clausewitz, Nonlinearity, and the Unpredictability of War"; International Security; Vol 17, No. 3; Winter 1992-93.

## ... or STRANGE ATTRACTORS

In the introduction to this paper, I stated my purpose as turning the concept of the COG upside-down. Essentially, I want to suggest that the notion of a center point with power emanating outward is replaced by one that attracts elements of power toward itself. One might ask, is this not a picture of a physical center of gravity? The answer is, of course, yes. However, one must understand the nuance in this description. For instance, a galactic mass does exert gravitational force on smaller masses that in turn, have their attributes and movements physically constrained. This is a perfect picture for the Clausewitzian metaphor of a hub of all power and movement.

Alternatively, in a human social sense, a mass is a normative construct. By that I mean, the collective "we" give some value to what we perceive. It can be explained in the old "which came first?" adage, or "a chicken is an egg's way of making another egg." Therefore, when we consider the use of military force, it is a matter of perspective in deciding where enemy power resides; regardless of the level of conflict. This is why we debate the choice of committing force. Additionally, it illustrates why COGs tend to proliferate as we move from the strategic to operational level and why they shift as the phase of the conflict proceeds. As a result, the conceptual idea becomes more of an academic exercise and less of a fundamental, indeed required, concept in warfare.

Therefore, I believe the concept of the attractor will alleviate some confusion at this theoretical level. As with all new concepts, definitions take time to gain acceptance. However, one to start with is:

"A bounded region of phase space to which all sufficiently close trajectories from the basin of attraction are attached. A collection of isolated fixed points is no attractor."<sup>7</sup>

This is a good definition for our purposes and I will break it down into plain English to help us see why attractors are important.

To understand a **phase space** think about a system: military, political, or otherwise. All systems will have certain inherent properties or **phase variables**. All those individual variables and all their possible combinations make up the phase space.<sup>8</sup> There are two important concepts to note here. The first is, regardless of the number of variables in a system (it may have relatively few), the phase space may have the capability to produce a large number of possible conditions or states. The second is, regardless of the number of such conditions, there is still a limit to the

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<sup>7</sup> Schuster, Hein Georg; Deterministic Chaos; 2nd ed.; New York; VCH Publishers; 1989; pg. 105 (An adaptation that excludes some data, however the principle is captured.)

<sup>8</sup> James, Glenn E.; "Chaos Theory: The Essentials for Military Applications"; Unpublished Research Paper, Naval War College, Newport, R.I.; 1995; pg. 42

system because it is bounded (constrained). The system can not go outside itself to get more variables. Hence, regardless of the number of combinations, they represent all that are available and no more.

This appears to represent a starting point in one of the most difficult exercises military professionals face; translating the strategic political goals into an operational strategy to achieve the desired military end state. Does considering, debating, selecting, and rejecting different COGs fill this bill?<sup>9</sup> Perhaps, but it would appear that the wiser course is to first understand your enemy (*Sun Tzu*) by considering his Trinity (*Clausewitz*) or any other variables that are relevant. By defining what you confront, you become sensitive to the possibilities rather than getting locked into a standard text book answer.

Furthermore, this level of analysis does not stop at the hazy line that divides strategic from the operational. On the contrary, the force confronting you is also made up of several variables. These may be components of the armed forces, their technical capability, level of morale, training, reserves, etc. There are several possible combinations; some more or less concentrated or in some other way important. However, it is critical to note that it's aims and objectives are defined under a bounded set of conditions.

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<sup>9</sup> Mendel, William W. and Tooke, Lamar; "Operational Logic: Selecting the Center of Gravity"; Military Review; June 1993; pg. 5

Now, let's deal with trajectories. To do this, think back to graphs. We are all familiar with the two-dimensional sort with X and Y axes. The dimensions of these axes represent the value of a particular variable. At any given moment, a plot of the value combination of these two variables is represented by a point. If we continue to plot different combinations of the variables over some length of time, we'll come up with a collection of points. It is these collection of points that define our attractor. Additionally, when we connect these points on a best fit curve or line we have displayed a trajectory.

Well, that's fairly easy to see until the system you are defining has more than two or three variables. However, the concept of a trajectory within a phase space is still worthwhile. This is because each of the primary variables, (*such as the Trinity concept*), is, itself, a combination of sub-variables. Furthermore, to focus on certain key variables may tell you what you really need to know. This is because, these key phase variables are derived from the nature of the attractor. In essence, it is a two way street. If you know the variables, you understand the attractor, and visa versa.

To illustrate, assume that at the strategic level, a state's goal is territorial expansion. Some variables that suggest themselves are level of military expenditure, the technological rating of the forces being bought, and the level of belligerent political activity. As we change scale to the operational level, the technological rating of that military force might be broken

down into variables such as an appreciation of the speed that those forces can be deployed, that force's doctrinal idea of employment, and the level of sustainability of those forces. There may be other variables that come to mind. The point is, that "stuff" doesn't just happen. The attractor, at a very basic level, is the foundation for whatever collection of points or trajectories that *can* occur.

In the example above, the territorial ambitions of this imagined state were the basis of the attractor. So, it would appear that this is a rather straight forward exercise. We might consider using this linear method for determining a COG. Unfortunately, our experience tells us that human activity is not nearly so straight forward. Additionally, our basic definition contains the phrase "sufficiently close" trajectories. It is that word, "sufficiently" that will cause a great deal of ambiguity.

To start with, if every system could always operate under the same conditions all the time, it's trajectories would always be the same; the trajectory would always visit every point on the attractor. However, most systems we deal with are not afforded that consistency. For instance, if we started up and ran any particular system under different starting conditions than a previous run, a comparison of the two trajectories would show a divergence. To extrapolate, for one particular question: (What is my COG?), the possibility exists that we would get two different answers: (At first it seemed to be their army, but later it appeared to be centered on the public. Their frustration over the

huge tax burden eventually forced the government to reduce the army's capability.) The characteristic that can skew these trajectories is known in Chaos Theory as **sensitivity to initial conditions**.

What this sensitivity implies is, that despite the fact that the phase space or variables have not changed, the attractor looks "strange." That is, the trajectory started off in different region of the phase space. Though the nature of the attractor is similar, it's appearance is modified. This collection of starting points off the attractor is known as the **basin of attraction**. However, all these possible initial states will eventually lead trajectories to exhibit the same **dynamics** on the attractor,<sup>10</sup> if not necessarily the same trajectory. Moreover, we should also be aware that the initial condition, with regard to time, can be arbitrarily set. It is important to get agreement on the initial frame of reference. Lacking that agreement, a certain amount of confusion will exist between two different on-lookers as they try to decide what the trajectory is telling them. Additionally, all systems, whether presently running or just at initiation, will have to deal with a certain amount of feedback. This feedback might be external in origin or as result of the system's internal functions.

To see how this affects a system, let's consider the following. Left to itself, a trajectory will always return to every point of the attractor unless it's perturbed.<sup>11</sup> The

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<sup>10</sup> James; pg. 47

<sup>11</sup> James; pg. 46

perturbation can happen because while a variable may exist in one system's phase space, it is also possible for that variable to be shared in others.<sup>12</sup> That is, as two attractors are "running", it is quite possible that a value of a variable in one phase space will affect the value in the other; thereby skewing the trajectory of the effected attractor. For example, the occupation of a specific piece of territory (phase variable) by one side, will affect the strategy (trajectory) of the other. In other words, the piece of territory may seem like a COG for some amount of time. Later, at some point in time when the territory is occupied by the other side, the designation of the COG will change. Therefore, taking into account the preceding discussion, "sufficiently close" might be very broad indeed. As long as the nature of the attractor has not radically altered, any group of trajectories represent a possible representation of a system's output.

This is the pay-off for operational art; while the strange attractor is not going to behave in ways that are precisely predictable, they will behave in a generally deterministic manner. Therefore, this concept shows promise as we attempt to trace an operational plan to what we used to think of as a center of gravity. We can bridge the gap between strategic and operational objectives. Selecting COGs will be less a matter of guess work and more of a reasoned approach. We will still debate the issue of applying force. However, that debate will focus on pragmatic

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<sup>12</sup> Peitgen, Heinz-Otto and others; Chaos and Fractals: New Frontiers in Science; New York; Springer-Verlag Inc.; 1992; pg. 757



issues and not the abstract and theoretical. Additionally, COGs won't proliferate. They will be what they always were; operational and tactical objectives in the pursuit of affecting the enemy's will to fight. The key is to determine and trace those objectives that will have a marked effect on the enemy's attractor and the leverage we seek.

## CONCLUSION

Determining COGs is a difficult process. It relies, to some extent, on guess work. This is because a linear concept is applied to a nonlinear activity. In retrospect, the COG as a valuable theoretical construct is in danger of turning into the more concrete concept of battlefield objective. And, as we are all aware, winning on the battlefield does not always lead to victory.

The concept of attractors captures the essence of Clausewitz's thought as well as our own experience. Although it is somewhat simple in definition, behind the words are the complicated nuances that all nonlinear systems display. However, despite the complexity, the basic elements that make up attractors are known. In a rather straight forward manner, one can trace the evolution of a system from it's inception. With the knowledge of those elements, comes an understanding of the characteristics that may be susceptible to control or modification.

I hope I have demonstrated that the vocabulary of Chaos Theory is not just something new to explain the same old thing. The words are new, but the underlying concepts and the insight they bring us, are new as well.

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